Imitative Learning in Robotics

Research Proposal · October 2020

DOI: 10.13140/RG.2.2.30232.01285

1 author:

Raj Kishan K
St. Joseph's College of Bangalore

Synopsis

The human species have been far superior then their fellow beings because of a simple reason, Intelligence. In my point of view, the day where humans and robots socialize isn't far away. But one major reason why we haven't been able to make them more efficient is dynamic interpretation and understanding. The robots unlike humans, don't have any intelligence of their own, thus they need to be taught even the most basic thing, therefore making it a very complex process. We wouldn't have to teach it, if the robot has the capability to interpret its surroundings and generate the data from it and understand itself.

The topic is closely related to three fields, Psychology, Computer science and Cognitive science. Unlike humans, robots don't experience emotions, they have to be stimulated externally and a branch called Affective Computing or commonly Artificial Emotional Intelligence which deals with development of systems through which a robot can resolve and analyse human effects, thus making emotion a social construct to deal with.

These emotions help the robot to analyse its surrounding better and perform accordingly while also teaching itself what that particular emotion is and how humans behave when they pass that emotion. The problem with dynamic analysis is it has to take place extremely fast, the human brain is a very complex and extremely fast organ with interconnections of billions of neurons with the potential to resolve major tasks into simpler modules and finish them in fractions of seconds with the help of nerve impulses. As a result of this speech, vision, physical touch, sound and memory are happening simultaneously with monitoring done by the brain. The robot requires a very strong and powerful interpret algorithm to work these factors without human aid or assistance.

Thus in this term paper I'm going to present my ideologies on how the robots with the power to learn, touch and imitate the characteristics around them, they can be more effective and potentially capable of resolving many advance scientific research and data analysis and can be further implemented into almost every field of human life with full control over them.

The vision of robots being able to classify emotions, body, faces and also understand the necessity of them and how can they be trained to do imitative learning with the help of technology is my area of research in this term paper.

Table of Contents:

1. ***Introduction:***

A robot is defined as “a machine that can perform a complicated series of tasks automatically,” by the Oxford Dictionary and “actuated mechanism programmable in two or more axes with autonomy, moving within its environment, to perform intended tasks,” by the International Organization for Standardization.

Thus, in a general Perspective, a Robot is guided by Programmable instructions to perform an intended task.

Robotics, on the other hand, is defined as “science and practice of designing, manufacturing, and applying robots” by ISO. Going further ahead we’ll dive into what are robots made up of, how do they learn and what are the applications of it.

1.1 Basic Components of a Robot:

The Robot constitutes of thousands of small particles integrated to perform major applications, However, there are some components almost all Robots will have, i.e.

A) Central Unit:

Figure 1: Control Unit

The above image is just an example of how Control Units look, In real time, There are no compulsory designs a Developer should follow as it is based on the convenience and the efficiency of the Robot.

- This is the Coordinating, Manipulating and the Processing unit in a Robot.
- It makes all the decisions of the functions and behavior of the Robot.
- This interacts using multiple input and output syntaxes/devices.
- After the input is processed it triggers a Motion (Function) or necessary unit to perform a task.
- It commonly uses Microcontroller (Sensors) to detect the Input or the output, commonly used ones are Light, Sound, Optical Data, Temperature.

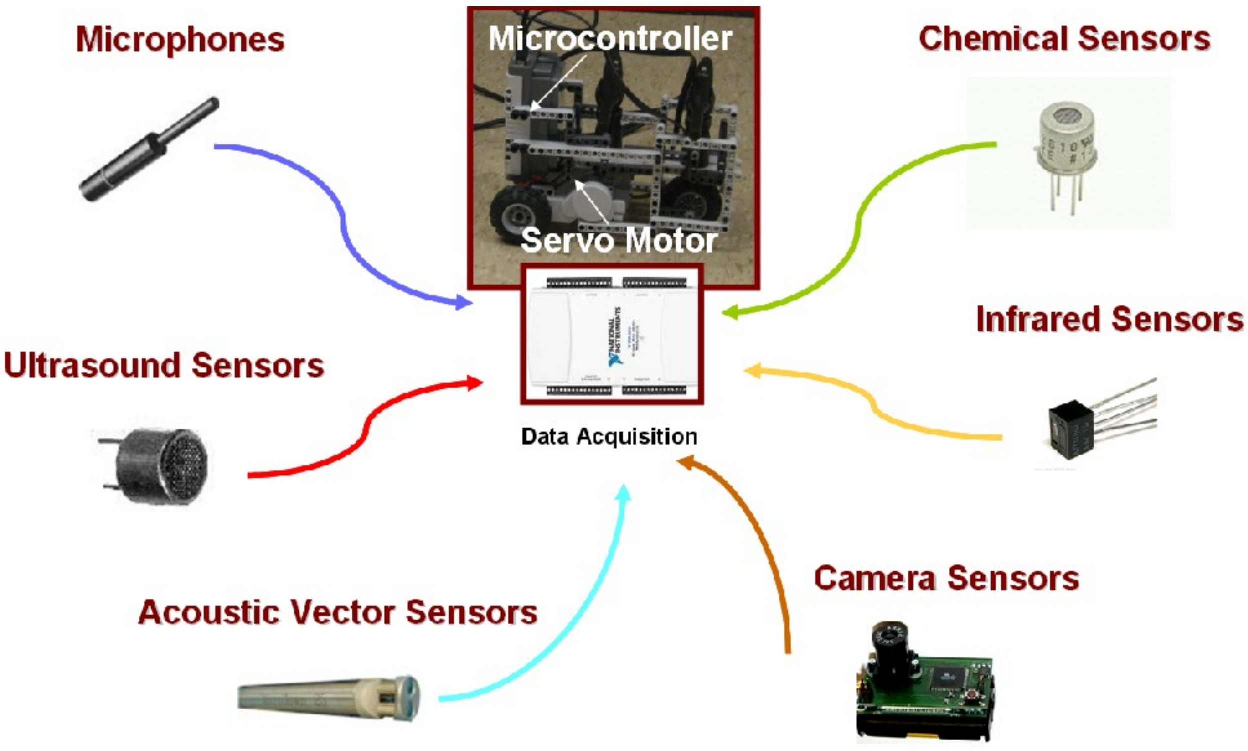

Figure 2: MicroController

B) Body:

Contradictory to the Imagination of people, Most Robots aren't shaped similar to human but rather an assembly of machines and hardware components.

Figure 3: Body of a Robot

- The body of the Robot can be of any shape or size.
- They are usually composed of Metal (frame), Threads or wheels, Hardware units like the central unit, Memory Disk, Wires, and connections.
- Actuators, that mimic the action of human muscle for the movement of the Robots.
- Energy Source is a key part of the Robot. Most robots work on Electricity or Plug-in batteries.

C) Manipulators:

To achieve high efficiency, the Robots interact with the surrounding environment, and complete tasks based on them. To achieve that, there are many Devices or Drivers that are additionally inserted into the Robot.

- End Effectors are the parts of the Robot that let it interac

-
- t with the environment and perform required tasks. For example, Robots in Factories have to be Spray Paint based on the Product or A Robot in outer space that detects and studies it's the environment.
- Drivetrain: Although most Robots are stationary, Some Robots require moving around, for such Robots Drivetrain comprises a Powered ability to move around similar to human legs.

Figure 4: Drive Train of a Robot

1.2 Classification of a Robot:

Robots are not strictly classified into categories because of their diverse functions, However, they are generally clubbed into 2 Divisions, Namely

A) I**ndustrial Robots:**

Industrial Robots are Robots that are generally used in Production and Manufacturing. They are used to replace Humans and thus mimic Human Activity. They are programmed for automation and generally use Axes for doing their Functions. They help reduce Human demand and increase while improving the Cost and Production standards, thus they are widely used in large-scale production.

Figure 5: Industrial Robot

There are many types of Industrial Robots, Few of them are,

- Articulated Robot: They are multi-jointed that interact with materials and work in a stationary setup.
- Assembly Robots: Commonly known as SCARA (Selective Compliance Assembly Robot Arm) are Robots that are used in the production of Automobiles or any industry that requires Parts to be Selectively Assembled.
- Parallel Arm Robot: They are structured similarly to the human arm with 3 fingers and are connected at the bottom. They are used in Packaging as they can turn around in different Orientations.
- Cartesian Robot: Popularly known as x-y-z Robot, as they use the Co-ordinate system to move linearly. They are one of the most researched robots as there are many applications including 3D-printing, CNC Machine.

B) **<u>Service Robots:</u>**

Service Robots are typically assist humans in daily day activities. They are usually automated with built-in intelligence or service tasks to ease human efforts. They interact, communicate, and adapt to the surrounding environment.

Some characteristics of Robots are,

- Autonomous decision-making abilities.
- Automated social presence (ASP) is the ability of a Robot to mark itself as a Social Entity.
- They are part of a bigger Intelligence System.
- Can perform cognitive/analytical or emotional/social tasks.
- They have 4 levels of intelligence,
    1. Mechanical intelligence
    2. Systematic or Analytical intelligence
    3. Creative Intelligence
    4. Emotional Intelligence
- Have limited physical functionality.

There are many types of Service Robots based on the functionality, Namely

- Education/Learning-based Robots: They are used in universities, colleges to help teach, grade, and give practical real-time education to students.

1.3 Evolution of Robots:

Ancient times:

The study of robotics and robots claim to have started in Greece and Egyptian mythologies, including the prominent binding to God's for creating them. For instance, the legends of Cadmus and Hephaestus creating a three-legged table that could move with autonomy and the legend of Talos who eventually destroyed an entire army by making a bronze man.

There has been evidence of Daoxuan (596- 667 AD) describing a humanoid machine made of metals and sacred texts. Even in the Chinese lore, there have been instances of humanoid and autonomous machines being used for various tricks in the king's court. In the Indian collection of Lores, "Bhuta Vahana Yanta" meaning a spirit of machines that can move has been quoted in the crafts of the Buddha Stupa.

Modern times:

In the 1900s the study of Robotics and autonomous bodies grew to a large extent because of the books and novels that came out during that phase, "The Wonderful wizard of Oz" dealt with a Humanoid (Robot) in the forest.

With the World War 1 starting, there were many scientific discoveries, including the marvelous works of Nikola Tesla who had contributed extensively in his field of study.

However, the term Robot first rose to light when it was used in a famous play, “Rosssum’s Universal Robots” by the Czech (Karel Capek) in the year 1921 discussed robots as biological beings and slaves of Humans. The word was made from 2 languages, Czech language and Slovak, which more or less meant a free, unpaid labour. Isaac Asimov later used the word in a robot story called “Liar!” in 1941.

From the 1930s, the study of industrial robots and its implications reached great heights. By this time, we could already develop a shoulder or arm-based kinetic repeated motion. Motions could be controlled through cam and switch programming.

The first patent for an autonomous arm based machine was by “William V Pollard” for his “Positioning Controlling Apparatus” made from mechanical, electrical and pneumatic cylinders and controllers.

Below I’ve made a timeline of prominent marks in the history of Robotics and Robots: starting from 1645:

- 1645 - “Pascaline” by Blaise Pascal was the first calculating machine.
- 1865- “The Steam Man” by Issac Grass used to pull a cart.
- 1937- “Elektro” by Mansfield plant could perform 26 different operations.
- 1942- “First Programmable mechanism” was a paint sprayer by DeVilbiss Company.
- 1948- “Elmer & Elsie” the first robots that could think by William Grey Walter.
- 1971- “WAP - 3” by Light Weigh Model could move on the frontal plane
- 1996- “RoboTuna” by MIT could move similarly to a fish in water.
- 1997- “Path Finder” by NASA was deployed in space.
- 2002- “ASIMO” by Honda was the world’s first personal assistant robot.
- 2011- “hitchBOT” by McMaster University and Ryerson University was the first social robot.
- 2014- “Pepper” by SoftBank Robotics was the first robot that could read emotions significantly.
- 2016- “Sophia” by Hanson Robotics used ML-AI extensively to communicate.
- 2020- “Surena IV” by the University of Tehran is the most advanced robot in the world alongside ASIMO.

2. Working Principle of Robotics:

There is no particular structure or standard on how a robot should exist, However I have taken a general case of and explained further:

2.1 Hardware:

Hardware or the physical components helps us in classifying and understanding better about how robots work.

2.1.1 Human Structure:

Below I've illustrated the similarities between the structure of a human and a robot as it is very keen to understand how Robots work.

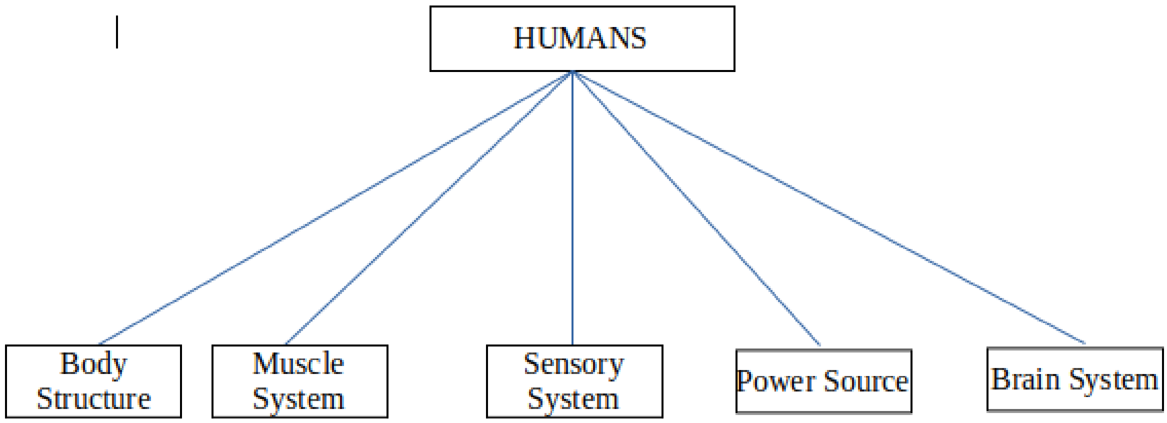

Figure 6: Human Physical Structure

As we can identify from the above illustration, all the characteristics and physical components of the human come under these 5 Categories.

They are,

- Body Structure: made from bones and tissues which give us our physical structure.
- Muscle System: help us perform muscular or kinetic actions with the help of the physical structure
- Sensory System: plays a vital role in performing every task.
- Power Source: Oxygen, Food and everything that is needed to give us the energy to perform actions.
- Brain System: Responsible for taking decisions, giving instructions and everything we do.

2.1.2 Robots Structure:

Below, I've illustrated the key physical components needed for a robot to work.

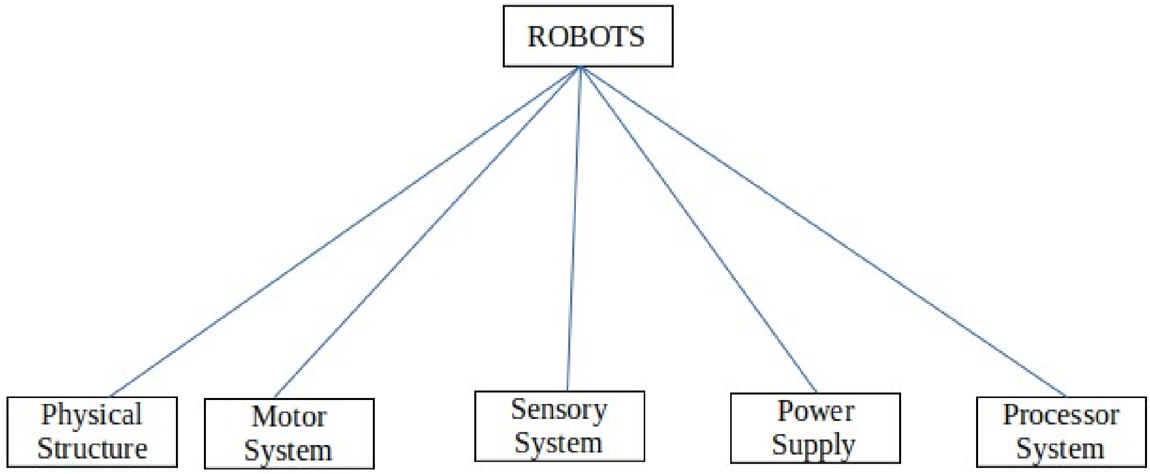

Figure 7: Robot's Physical Structure

As we can identify from the above illustration, the robot's physical structure is very similar to human's physical structure.

To understand the components,

- Physical Structure:
    - Present in the most external part of the robot. Usually from different Metals or Poly Carbonates.
    - Also comprises Electrical Circuit, Valves, Pistons for performing tasks.
- Motor structure:
    - They intuse physical movement and multiple actions upon the instructions of the processor.
    - Known as Actuators.
    - Common ones are Electric Motors, Solenoids, hydraulic system, pneumatic system based actuators.
    - Perform the actions of a joint in Human Body.
- Power Source:
    - Supply energy to the robot to function.

    - Act as a battery and store energy.
    - Advanced robots use Hydraulic Fluids and pneumatic (Compressed gas) based power sources.
- Sensory Systems:
    - Collects required data from surroundings and transmits to the processor.
    - Common Sensory systems collect data related to light, pressure, sound, and smell.
- Processor System:
    - Responsible for making decisions.
    - Gives instructions based on data collected.
    - Handles the Intelligence part of the Robot.

Basic structure is stated above, However many robots have their own customizations and can use these in infinite ways to perform complex actions.

2.2 Software:

The Robot is programmed to perform certain tasks, and the processor acts as the Central Processing Unit and handles all the programs and the tasks.
The Processor is the brain of the Robot; It stores the data and makes the decision using algorithms and conditional statements.

I'm not going in great detail about exactly the decision is made, But I'll give a simpler structure of how it is taken.

The Processor receives data from the sensory systems, the following are the common data collected and given to the processor to process,

- Series of Lights Patterns (To identify its own position)
- Disturbances in the Sound Medium
- Steroed Vision (Camera sight)
- Pressure Grip
- Raw data needed from surroundings.
- Internal or Previous related data

This information act as the problem set for the processor, which upon certain conditional statements based on its function will get a set of workable solutions in terms of data. The processor then finds the optimal solution and invokes the desired part/set of instructions to be executed for the robot to function.

However, this is the general schema of the Working principle of a robot, each robot has its own functional abilities and customizations according to the need.

Modern Robots have additional functional ability like learning like observe and refine itself to perform better functions which I'll discuss in the next Unit.

2.3 DFD of Working Principle of a Robot:

Below I've illustrated using a Data Flow diagram of how data traverses inside the Robot, the functions of each parts of a robot and how they communicate among them.

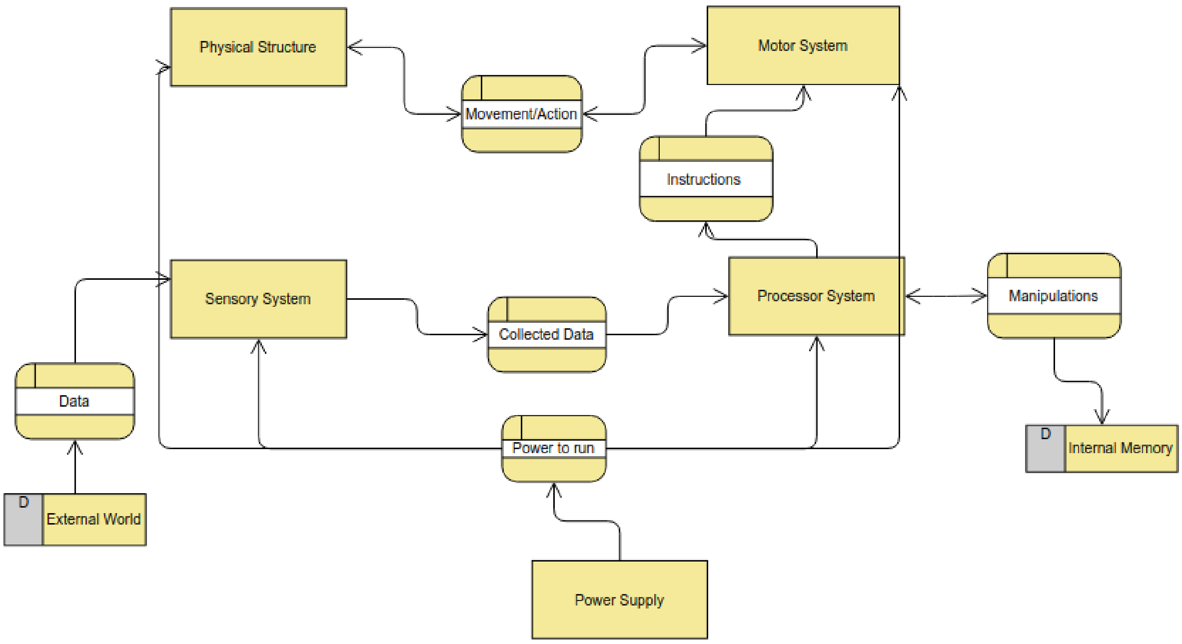

Figure 8: Data Flow Diagram of a Robot

3. Learning and Imitative Learning in Robotics:

In modern days, the limitation of having to instruct the Robot to perform certain tasks using Programming and them completely depending on us are gone, as Artificial Intelligence, Machine Learning and Deep Learning are extensively used to make the Robot an autonomously functioning machine with its own intelligence.

These machines/robots which can apply its own intelligence are called, “Intelligent Systems”.

3.1 Machine Learning:

We define Machine learning as “A sub-branch of Artificial Intelligence that allows the machine to learn and improve from its experience without having to program everything”. Machine learning is the scientific study of algorithms and statistical models that computer systems use to progressively improve their performance on a specific task.

All ML algorithms require data to learn. There are tons of data in the world, inclusive of texts, images, etc and only very little is labeled data, whether through programs or through traditional method.

For performing any calculations or manipulations we need algorithms, and labels are nothing but ideal data and while algorithms use various approach to find the optimal solution set, once we have this set, we can calculate the performance of accuracy by comparing Labels and solution sets. Using the refined set, we improve the algorithm while trying to minimize the difference between the label and the solution set. To do this, there are various approaches to ML, A few are,

- Supervised Machine Learning
- Unsupervised Machine Learning
- Semi-supervised Machine Learning
- Reinforcement Machine Learning

3.1.1 Supervised Machine Learning:

SML refers to the algorithm which trains itself based on preaccessible dataset and performs operations on them when dealing with new instances which result in general hypotheses of the outcome.

SML starts with identifying and collecting the required data, then Normalising (Cleaning of Data) and after that training the algorithm using the labelled set (Target values). After the learning process, we will get a refined solution set and an algorithm which can predict similar data that haven’t been labelled yet.

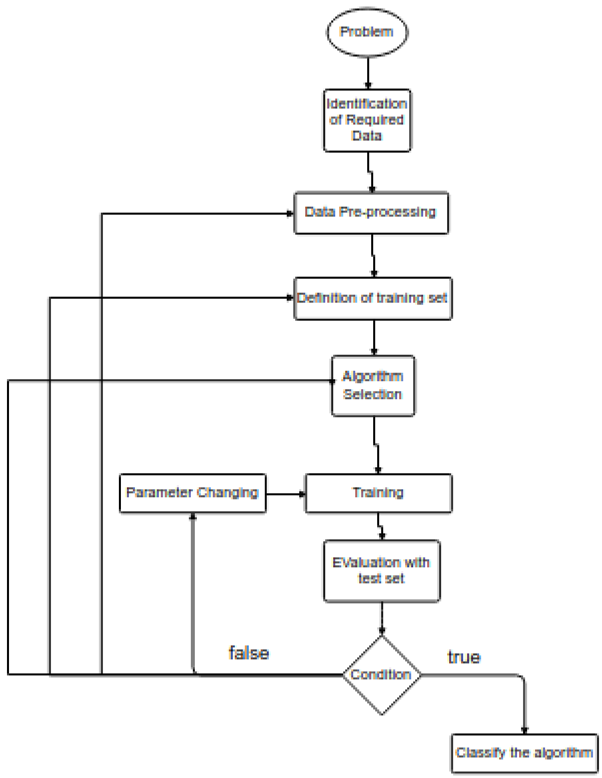

Figure 9: Flowchart of SLM

The above flowchart represents how SML algorithm works and how the training of new datasets with change in its parameters, testing the data with the pre-defined data set, changing the parameters for the same dataset.

As every time this process happens, the algorithm learns from the new dataset and refines itself. This is a continuous process because the upcoming algorithm is always or in most times better than the present one provided adequate and clean datasets are provided to the algorithm.

Thus this learning algorithm is the most used approach for a machine to learn in a labelled dataset approach.

3.1.2 Unsupervised Machine Learning:

We define UML as an algorithm used for finding patterns or gaining insights from data.UML works on a large dataset which cannot be labelled or is very hard to label.

In this algorithm approach, we don't have a pre-defined test set, or a labelled set. The solution set of this algorithm doesn't have one specific structured answer, but an inference from raw datasets.

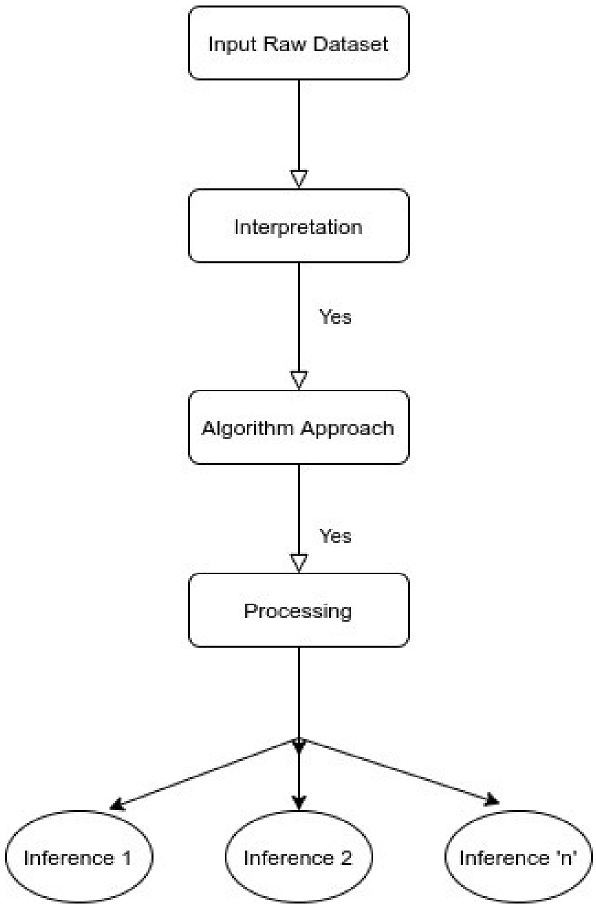

Figure 10: Flowchart of UML

The above flowchart represents how UML algorithm works and how when a raw dataset is given and the algorithm which has to be applied is specified, it generates the inference.

As every time this process happens, the algorithm has a baseline on how the actual refined dataset can possibly be and as it compares it to the raw data set, it'll raise a flag and create an inference which makes it useful in terms of fields like Cyber Security, Natural Language Processing.

3.1.3 Semi-supervised Machine Learning:

Semi-supervised Machine Learning can be defined as an approach to work on the unlabelled dataset to get a labelled dataset of optimal solutions.

This approach refines the problem of not having Labelled data by working on large unlabelled datasets together with labelled dataset to build the solution set and algorithms or more commonly known as classifiers. In simple words, it's a combination of both Supervised and Unsupervised ML approaches. Using Semi-ML, we can perform manipulations on the dataset and cluster the data into several categories based on the parameters selected.

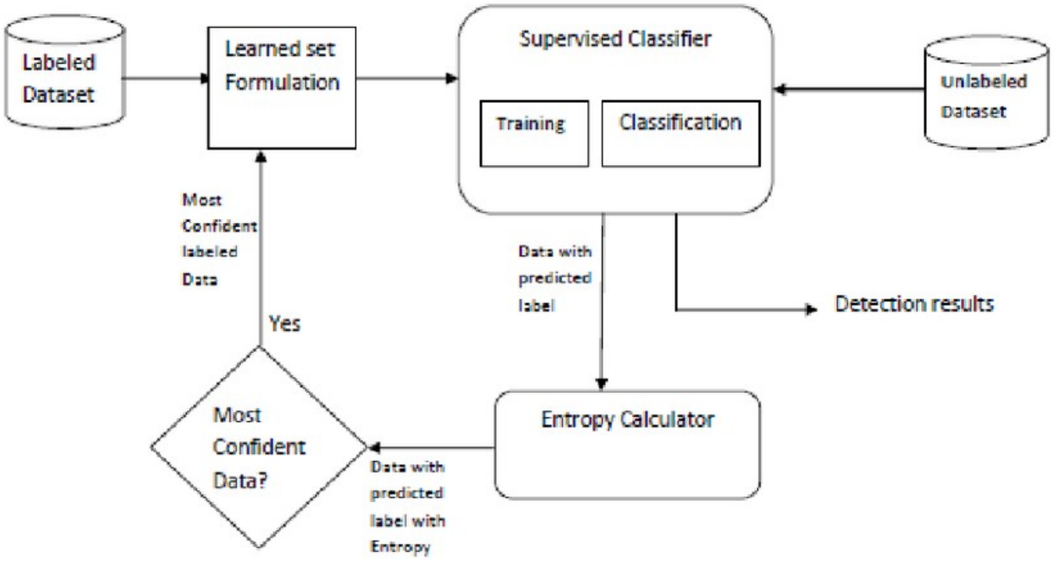

Figure 11: Flowchart of Semi-supervised Machine Learning

As we can observe from the illustration, Semi-supervised machine learning takes both Labeled data set and unlabelled data set, But while taking the labeled dataset, it has a previously learned formulation.

After the data is trained and classified, its checked for entropy and confidence of the algorithm, If the algorithm satisfies the required conditions and is in the most refined situation, it will be classified and the results will be detected.

3.1.4 Reinforcement Machine Learning:

RML is defined as “Trial & Error based” learning algorithm. The algorithm applies trial & error method to resolve the problem and find the optimal solution, Every time the algorithm is right, it gets a reward and if it’s fault, it gets a penalty. The goal of this algorithm is to minimize penalty and maximize rewards.

The dataset used to train here is usually uncertain and potentially complex situation. Because the algorithm is in continuous learning, we can classify the optimal algorithm easily.

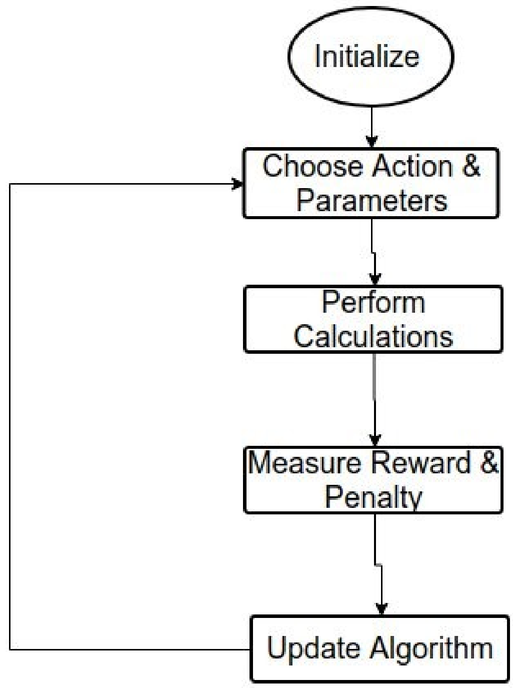

Figure 12: Flowchart of RML

As we can see from the illustration, once we choose the parameters and the action to be performed, the agent (algorithm) works by reinforcing (Trying again and again) and improves itself by measuring reward and penalty.

An additional advantage here is it learns from both positive and negative reinforcement, teaching the machine learn how to behave in certain conditions. This algorithm is useful in gaming, guiding autonomous bodies and many more algorithms based on deep learning and neural networks approaches.

3.1.5 Example algorithms used in ML

- Linear Classifiers
- Logistic Regression
- Naive Bayesian (NB) networks
- K-means
- Decision trees
- Neural networks
- Cluster Analysis

3.2 Deep Learning:

Deep learning is a sub-subject under Artificial Intelligence and Machine Learning. It deals with mimicking the human like intelligence based learning and decision making. It is widely used in Natural Language Processing, Identification of Objects, recognizing speech and much more. Deep Learning can draw inferences and train algorithms using both Structured and Unstructured learning. It also works on all kinds of datasets, including labelled and unlabelled.

Deep Learning functions by building Neural Networks similar to our nervous system with a web like structure. It can process data both linear and non-linear compared to other approaches of learning.

So, In brief, Deep learning is an additional approach to improve the learning algorithm and minimize the error rate.

3.3 Artificial Intelligence:

As I've previously mentioned what Artificial intelligence stands for, I'll explain the types of artificial intelligence and process of how learning converts into intelligence.

3.3.1 Types of Artificial Intelligence:

Below, I've mentioned about how they are related to learning and not in a general perspective.

1. **Reactive Machines:**
    - This is the most basic level of intelligence in a Robot
    - This doesn't involve in learning and thus doesn't have any previous datasets to refer to.
    - It is used to make predictions based on certain parameters in immediate situations.
    - It doesn't use the representational world, but the real one.
2. **Limited Memory:**
    - Secondary level of intelligence
    - Can work using previous datasets and instructions
    - But they cannot draw inference from the experiences
    - They work for identification or to give directions, for instance, in an autonomous body.
3. **Theory of Mind:**
    - They work on the representational world by having the real-world objects and agents as entities and parameters.

- Closely deal with thoughts, emotions because it uses speech recognition and multiple other factors to understand and build its dataset and algorithm
- It constitutes of learning process where it'll be able to communicate among machines and also humans.

4. **Self Awareness:**
    - The highest level of intelligence in a Robot.
    - Also known as Machine Consciousness (MC) deals with a machine's cognitive ability to think on its own.
    - Still in the development phase (Only in theory, There isn't practical and optimal implementation achieved yet).

3.3.2 How learning and intelligence connect:

In the longest standing debate of humans, "Nature or Nurture, what influences more? ", we can draw a connection to Robots and Intelligent Machines. In machines, because they don't carry their own intelligence, it's always nurtured intelligence or in more precise words, Inference learning.

When a machine learns, it improves its action algorithm, identifies key parameters and widens the boundary conditions of its input dataset while minimizing the redundant and error values. In this process of learning, the AI picks up these algorithms and when a future situation arises with a similar dataset; it applies the most optimal and suitable algorithm to derive the required result.

Though, it is still very unclear or under-researched on how connecting multiple datasets, performing parameter wise approach and choosing the right algorithm works, all we know is that the learning converts into intelligence which a machine uses when needed.

3.4 Imitative Learning in Robotics:

Imitative learning refers to the learning process when one learns by seeing/observing another person produce it. This is closely observed in humans, It is defined as an act where learning happens through imitating the characteristics/lessons/observations from another individual.

Imitative learning is seen in almost all intelligent species including Humans, animals and other creatures. We as children imitate our environment, our parents and others around us and perform actions similar to them and learn human behaviour.

Among humans, this approach of learning is also referred to as Social learning. In animals, this is the main form of learning, as they don't have a very effective way of verbal communication. Offsprings imitate Parent behaviour to learn required tasks to survive and pass it on to their offsprings for further existence as a species.

Imitative learning is closely associated to Personality development, Cognitive thinking, and Social behaviour in humans.

Imitative learning in Robotics refers to the approach where a robot learns from observing or by taking assistance from human to learn their behaviour, an approach towards that set of problems.

3.4.1 In Humans:

Imitative learning in humans has been seen even from very ancient times, ever since then we started developing from primates. There have been multiple studies where humans and animals have been studied together to see how effective this process of learning is.

Humans often imitate selectively based on their interests and ideals, usually they imitate a successful person or a celebrity they connect to most. Because they have a sense of learning, they can get from them and hoping they end up being the person they imitated.

Imitation isn't very simple in human brain, the temporoparietal junction is usually linked to the ability to control imitation. The process of the brain making the right connections while imitating learning is far more complex than one can imagine.

3.4.2 In Animals:

Animals use this learning approach much wider than human beings, they learn almost all their decision-making skills from this process. Even though they have their own intelligence, they usually can't be creative.

There have also been numerous studies that prove the same. Also, this learning approach originated from animals.

3.4.3 In Robots:

In artificial systems, especially Robots, the process of imitative learning is spontaneous. It deals with observing and learning while simultaneously processing relationships between different entities and building them in the representational world using analysis.

3.4.3.1 Observation:

The process of learning starts from having a observing pattern ready, and then it processes that information by drawing various parameter based agent matching.

There are multiple ways a robot will observe, they can be visual, auditory, sensual data, patterns or series of raw data based on the requirement.

For this to happen, the robot should be able to able to perform Object Recognition and distinguish between them. Object recognition is possible in Robots using Virtual neurotransmitters, which is derived from affective computing. Here the Robot will be able to identify using certain pattern or

conditional approaches and if it finds a similar search series or recognize the patter, it will use that to learn and record all the actions performed by it and if the pattern doesn't match, it will be checking for the next object.

In case of a photograph, it separates the photograph into texture, geometry and prominent key features and then identify them. Similarly, for each recognition approach, the algorithm is previously trained on identification and observing.

For an auditory based approach, it'll break down the sentences into words and words into small modules of pre-configured data which will help in identifying and understanding words.

In case of sensual patterns, especially seen in industrial robots, they observe using sensory data like light patterns, pressure point, force applied. Thus, observation is usually based on the defined purpose of the robot.

3.4.3.2 Learning:

Various algorithms and approaches are used to process the gathered data and learn from it. The above mentioned machine learning approaches can be used here to filter out the dataset and improve the learning process.

3.4.3.3 Building Relationships:

This acts as a vital role because in learning because in this process whatever the robot has learnt is being used in the representational world the AI has defined within to connect different entities and agents. Every real world object is represented in either agent or entity form in the representational world, thus the robot applies whatever it has learnt in the representational world to draw inferences from them and store and improve them if needed.

This analysis of observing, learning and building relationships among them constitutes imitative learning. Imitative learning is widely used in various fields to train a robot because it is the most effective approach towards machine learning and artificial intelligence in Robots.

Though this process requires more effort from human beings, it is considered as the least cost effective methodology of learning in robots.

In the upcoming section, I'll illustrate and explain the approach using a case study for further understanding of the process.

4. Case Study:

4.1 Definition:

Here, I’ve created a python program to take in a character and take our inference of what that character means and process it. This will make the machine understand what that character stands for.

I’ve done this to present how a machine uses a template dataset, and when we use these in our conversation later, it will be able to recognize what they are.

4.2 Preparation of Data:

I’ve considered connecting each character to its Unicode Value and store them, thus giving it a labelled dataset to categorize it into alphabets, numbers and symbols.

Thus, because it’s a spontaneous process of learning, I need not have an entire library of pre-defined categories of data or datasets.

However, it uses Unicode library to lookup each time it’s called.

4.3 Learning Process:

4.3.1 Algorithm:

This below mentioned algorithm is how a machine using a programming language learns a character and stores it in the dataset dictionary.

- Step 1: Start
- Step 2: Initiliaze 3 empty dictionary
- Step 3: Input a character
- Step 4: Choose to which set the character belongs to among Alphabets, Numbers and symbol0s.
- Step 5: store the unicode of the character in a variable
- Step 6: Add the Unicode mapped with the character in the related dictionary
- Step 7: Query if wanting to view what it has learnt.
- Step 8: Show learnt dictionary
- Step 9: Stop

4.3.2 Flowchart:

Flowchart:

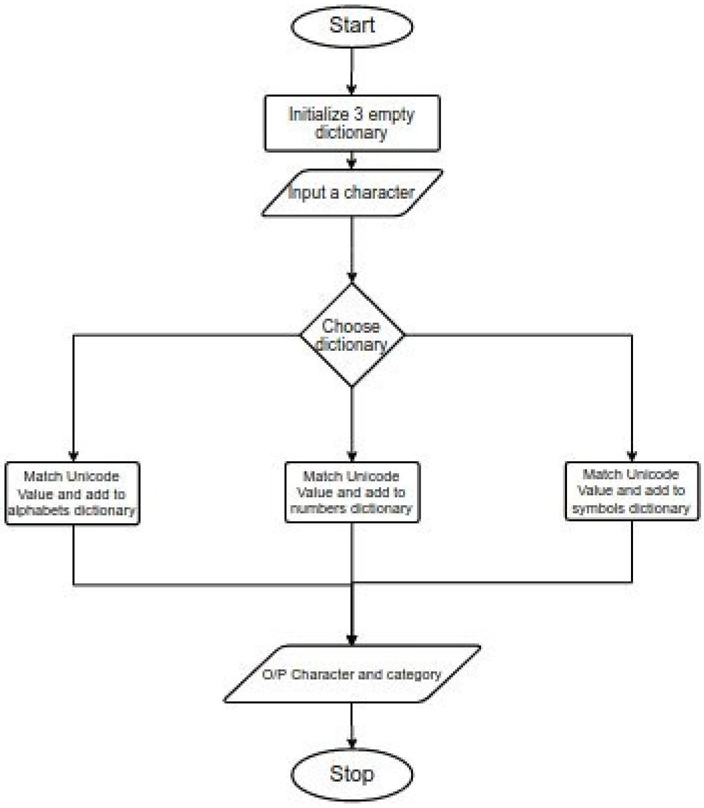

Figure 13: Flowchart (Case Study)

4.3.3 Program:

Below is a python program for the same:

```
alphabet= {}
number={}
symbol={}
data=input("Enter any character")
choice=input("If the character represents Alphabet enter 1, \n If the character represents Number enter 2, \n if the character represents Symbol enter 3 \n")
if (choice == '1'):
unicode=ord(data)
```

alphabet[data]=unicode

print(alphabet)

if (choice == '2'):

unicode=ord(data)

number[data]=unicode

print(number)

if (choice == '3'):

unicode=ord(data)

symbol[data]=unicode

print(symbol)

show=input("To show what the machine learnt, enter True if not enter False ")

if(show=='true'):

for key in alphabet :

print("The Alphabets are",key)

for key in number :

print("The Numbers are",key)

for key in symbol :

print("The Symbol are",key)

```
alphabet= {}
number={}
symbol={}

data=input("Enter any character")
choice=input("If the character represents Alphabet enter 1, \n If the character represents Number enter 2, \n if the character represents Symbol enter 3 \n")
if (choice == '1'):
    unicode=ord(data)
    alphabet[data]=unicode
    print(alphabet)
if (choice == '2'):
    unicode=ord(data)
    number[data]=unicode
    print(number)
if (choice == '3'):
    unicode=ord(data)
    symbol[data]=unicode
    print(symbol)
show=input("To show what the machine learnt enter True  if not False ")
if(show=='true'):
    for key in alphabet :
        print("The Alphabets are",key)
    for key in number :
        print("The Numbers are",key)
    for key in symbol :
        print("The Symbol are",key)
```

Figure 14: Screenshot of Program

The output of the program depends on the character entered, therefore I’ve attached a sample output to the above mentioned program

```
>>> %Run Program.py

  Enter any character4
  If the character represents Alphabet enter 1,
   If the character represents Number enter 2,
   if the character represents Symbol enter 3
  2
  {'4': 52}
  To show what the machine learnt enter True  if not False true
  The Numbers are 4

>>> |
```

Figure 15: Output of the Program

<u>4.3.4: Training:</u>

The above mentioned algorithm is just for training the program to take inference and learn, However, in extension and proper usage of Imitative Learning, the algorithm will use this dataset to learn and build upon itself.

The algorithm has to still be trained in speech analysis and there should be a dataset where all the dictionaries will be available for the machine to lookup and analyze.

The algorithm will be further trained under various parameters and actions to reduce redundancy and optimize recognition and identification.

<u>4.3.5 Performance Measure:</u>

The performance of this algorithm can be properly can be measured by the amount of the characters it recognizes and how many of them are correctly linked to the dictionary.

Further measure can be made on how fast it will be able to recognize and analyze each character.

<u>4.3.6 Datasets:</u>

The optimal datasets the current program can perform is only till every character has its Unicode value, because if it is not able to link the character to the Unicode value, it will not add it to the dictionary and it will not be able to recognize the character.

The dataset is also limited because it can currently analyze only 1 character, but in regular speech, there are characters which have more than character.

It is also limited by the contextual reference because the algorithm will not be able to recognize the situation and will link it to its literal value.

4.3.7 Validation:

Because it learns through imitation, there are very high chances the dataset might not be validated, thus we will use normalization before adding the data into the dictionary and thus eliminating repeated, unclear and false values.

4.4 Results & Inference:

We can clearly see that the algorithm and learning approach is still under development, so I'll draw my inferences from what is already done.

We can observe that we have taken human assistance and imitative learning mechanisms in this algorithm, Further We can also see it's a simultaneously improving algorithm because it works and learns continuously.

Future work:

- Improve Observing structure and implement more details.
- How data transforms from the learned dictionary to a stored dataset.
- Improvise training architecture to understand and solve complex sentences.
- Increase and optimize speed and data performance
- Install realtime validation of data to reduce redundancy.
- Practical implementation of the algorithm in Robotics.

5. Conclusion:

In this term paper, I’ve spoken about the Introduction of Robots and their subparts to understand their history and till where we have reached in developing an ideal functioning robot. I have went on to explain the working of a robot and how different parts of the robot have their own functions and how they are dependent on many factors.

Going ahead I’ve explained and illustrated of how Learning happens inside a Robot with Machine Learning, Deep Learning and Artificial Intelligence, With that as a base I’ve also briefed on how imitative learning happens in a robot, what are the factors it depend upon and what are the near future enhancements in the topic.

Further, I’ve written a python program to describe the algorithm of imitative learning in robotics and illustrated it with required data. I’ve also acknowledged and mentioned about the factors that have to be improvised and built better for practical implementation of this learning approach.

In conclusion, in this paper I’ve explained all required data, factors and instances where we can understand the implementation of Imitative Learning in Robotics and how the process is still under development.

I further also would like to quote that, In the future, I’ll work on a practical and much detailed approach towards Imitative Learning in Robotics and will further enhance the algorithm wherever necessary and this research (term) paper stands as a base for my future work.

6. Bibliography:

- https://www.iso.org/obp/ui/#iso:std:iso-iec:2382:-28:ed-1:v1:en
- https://www.iso.org/obp/ui/#iso:std:iso-iec:2382:-28:ed-1:v1:en
- Introduction : https://towardsdatascience.com/the-evolution-of-robotics-27539c5752fc
- History of Robots: https://en.wikipedia.org/wiki/History_of_robots
- Robots History: https://www.google.com/amp/s/spectrum.ieee.org/tech-history/dawn-of-electronics/elektro-the-motoman-had-the-biggest-brain-at-the-1939-worlds-fair.amp.html
- First Programmable Mechanism: https://www.sutori.com/item/in-1942-the-first-programmable-mechanism-a-paint-sprayer-was-designed-by-willa
- Working Principle: https://science.howstuffworks.com/robot.htm
- How robots learn: https://www.roboticstomorrow.com/article/2017/10/how-will-robots-learn/10833
- Machine Learning: https://expertsystem.com/machine-learning-definition/
- ML intro: https://medium.com/inside-machine-learning/placeholder-3557ebb3d470
- Supervised Machine Learning: https://www.researchgate.net/publication/318338750_Supervised_Machine_Learning_Algorithms_Classification_and_Comparison
- Unsupervised Learnng: https://ieeexplore.ieee.org/document/8713992
- Semi ML Flowchart: https://www.researchgate.net/profile/Vaibhav_Khatavkar/publication/267688382/figure/fig1/AS:295556674015232@1447477610105/Architecture-for-semi-supervised-IDS-using-self-learning-algorithm-SLA.png
- Flow charts: https://blockgeni.com/advancing-self-supervised-and-semi-supervised-learning-with-simclr/
- Semi ML: https://minds.wisconsin.edu/bitstream/handle/1793/60444/TR1530.pdf?sequence=1
- Reinforcement learning: https://deepsense.ai/what-is-reinforcement-learning-the-complete-guide/
- Reinforcement learning: https://www.researchgate.net/publication/338686816_A_Survey_of_Reinforcement_Learning_Techniques_Strategies_Recent_Development_and_Future_Directions
- Imitative learning: https://www.researchgate.net/publication/2775330_Imitative_Learning_Mechanisms_in_Robots_and_Humans
- Deep learning: https://www.investopedia.com/terms/d/deep-learning.asp#:~:text=Deep%20learning%20is%20an%20AI,is%20both%20unstructured%20and%20unlabeled

- Types of AI: https://www.govtech.com/computing/Understanding-the-Four-Types-of-Artificial-Intelligence.html
- Imiatitive learning: https://www.eva.mpg.de/documents/Springer/Over_Imitative_Encyclopedia-of-the-Sciences-of-Learning_2012_1567316.pdf
- Visual Communication: https://link.springer.com/referenceworkentry/10.1007%2F978-1-4419-1428-6_607
- Imitative learning: https://www.sciencedirect.com/topics/social-sciences/imitative-learning
- Imitative learning: https://link.springer.com/referenceworkentry/10.1007%2F978-1-4419-1428-6_758#:~:text=Imitation%20learning%20(IL)%20as%20applied,of%20search%20spaces%20for%20learning.&text=Imitation%20learning%20offers%20an%20implicit,can%20be%20minimized%20or%20eliminated.
- Imitative learning example: https://link.springer.com/chapter/10.1007/978-3-540-74024-7_5
- Imitative learning in Robots: https://link.springer.com/chapter/10.1007/978-3-662-05594-6_17
- Brain durig imitation: https://blogs.surrey.ac.uk/psychology/2013/11/08/new-paper-brain-stimulation-experiment-reveals-brain-area-involved-in-controlling-imitation/